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Semiannual Technical Summary

DARPA/TTO Program
IR Binary Optics

30 June 1984

Lincoln Laboratory

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LEXINGTON, MASSACHUSETTS

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FOR THE COMMANDER

Thomas J. Alpert

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

DARPA/TTO PROGRAM
IR BINARY OPTICS

SEMIANNUAL TECHNICAL SUMMARY REPORT
TO THE
DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

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LEXINGTON MASSACHUSETTS

ABSTRACT

This report describes the work performed at Lincoln Laboratory under the sponsorship of DARPA/TTO during the period 1 January through 30 June 1984.

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IR BINARY OPTICS

1. INTRODUCTION

Binary grating optics consist of microfine rectangular (high-low) relief patterns on a dielectric or a metallic surface. By controlling the depth, width and periodicity of the binary pattern, the amplitude and the phase of an electromagnetic wave can be controlled to produce a variety of optical transfer functions. The lithographic tools for fabrication of binary optics are the ones developed for VLSI circuit fabrication. From a single lithographic mask, planar replica optics can be made in quantity. This technology has broad applicability for tactical missile systems as well as for space systems. Working experimental devices today are in the infrared, but improvements in submicron lithography offer the fabrication technology to make optical devices in the visible.

In addition to making optics cheaper than by conventional means, binary optics allows the fabrication of unique devices that cannot be made conventionally. These include high-speed rotary scanners, multiplexers, filters, beam shapers and coherent laser adders.

The goal of this program is the development of high quality planar optical components using VLSI circuit fabrication techniques. The main elements of the plan are (1) the development of large aperture segmented and piezoelectrically active planar optical surfaces, (2) the development of raster scanning laser telescopes and extension to broadband applications, and (3) the application of diffractive optics technology to the coherent addition of beams from modular laser systems.

This report covers progress in the setup of a reactive ion-beam etching laboratory, and the feasibility demonstrations of the coherent beam addition concept with gas lasers. → next p.

2. REACTIVE ION-BEAM LABORATORY

In the past we have used existing laboratory facilities on the MIT campus and in the Solid State Division at Lincoln Laboratory. The delivery time of wafers with relief patterns (lenses and beam adders) was very low. Typically it would take two months for a single wafer to be delivered. Variational and optimization studies on depth, aspect ratios, coating materials, aberration corrections, etc. require a rapid source of trial devices. The main bottleneck has been the resist deposition, reactive ion-etching and the thin-film sputtering steps. We have purchased a Perkin-Elmer Model 2400-8L reactive ion-etcher (RIE) and thin-film sputter system. Equipment installation in the new fabrication laboratory will begin in December 1984. Of the major equipment items, only a scanning electron microscope is still out for bids. With this laboratory we will be able to fabricate the binary optical elements up to 7″ in diameter on the three dielectric materials of primary interest (Si, glass, and GaAs).

In addition to the equipment purchases, we have hired a technician familiar with optics and grating fabrication techniques who has extensive clean-room experience. He has made these binary optical devices for us in the past at the MIT campus. With him and the RIE equipment we will be able to fabricate devices (etch and thin-film deposition steps) during the second quarter of FY85.

A laboratory setup for testing a multibeam monolithic laser diode addition process is also underway. Diodes have been purchased and tested. Accurate AR coating of the array is the critical step in the phase locking process.

Analysis and preliminary tests on other non-holographic binary optical elements for coherent addition have also begun. The devices use straight-line binary gratings and use their zeroth or higher diffraction order for feedback control.

W. Veldkamp

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